Example

January 15, 2017

1 Trajectory Segmentation

Given two trajectories $\mathbf{R}^1 = \{r_1^1, r_2^1, r_3^1, r_4^1, r_5^1, r_6^1\}$ and $\mathbf{R}^2 = \{r_1^2, r_2^2, r_3^2, r_4^2, r_5^2, r_6^2\}$ (Table.1). We are able to identify stay places for each person. People may leave house A at morning, work at B and go home after work. Then we employ trajectory segmentation method to detect stay places such as A, B, C. The trajectories are partitioned into stops and moves.

$\mathbf{R}^1$	Location	Time
r_1^1	A	00:00
r_2^1	A	07:45
r_3^1	B	09:00
r_4^1	B	17:00
r_5^1	A	18:15
r_6^1	A	24:00

$\mathbf{R}^2$	Location	Time
r_1^2	C	00:00
r_2^2	C	07:45
r_3^2	B	09:00
r_4^2	B	17:30
r_5^2	C	18:45
r_6^2	C	24:00

Table 1: Trajectory $\mathbf{R}^1$ for person 1 and trajectory $\mathbf{R}^2$ for person 2.

$\mathbf{R}^1$	Time	Path	Flag
$R_{seg_1}^1$	00:00 - 07:45	A	stop
$R_{seg_2}^1$	07:45 - 09:00	A - B	move
$R_{seg_3}^1$	09:00 - 17:00	B	stop
$R_{seg_4}^1$	17:00 - 18:15	B - A	move
$R_{seg_5}^1$	18:15 - 24:00	A	stop

$\mathbf{R}^2$	Time	Path	Flag
$R_{seg_1}^2$	00:00 - 07:45	C	stop
$R_{seg_2}^2$	07:45 - 09:00	C - B	move
$R_{seg_3}^2$	09:00 - 17:30	B	stop
$R_{seg_4}^2$	17:30 - 18:45	B - C	move
$R_{seg_5}^2$	18:45 - 24:00	C	stop

Table 2: Trajectory segments for person 1 and person 2.

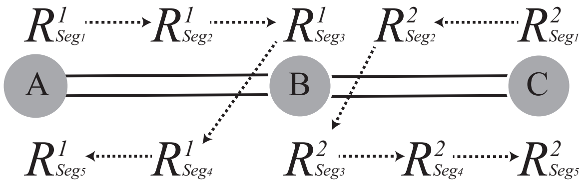

Figure 1: The result of trajectory segments.

2 Mobility pattern construction

A set of mobility patterns can be computed by clustering the segments based on their feature vectors. We assume that trajectory segments are grouped into several mobility pattern in table 3.

Mobility patterns	Trajectory segments	Flag
MP_1	$R^1_{seg_2}, R^1_{seg_4}$	move
MP_2	$R^2_{seg_2}, R^2_{seg_4}$	move
MP_3	$R^1_{seg_3},R^2_{seg_3}$	stop
MP_4	$R^1_{seg_1}, R^1_{seg_5}$	stop
MP_5	$R^2_{seg_1},R^2_{seg_5}$	stop

Table 3: The result of clustering algorithm.

Then we will compute mobility vector for each trajectory segment (Table 4). The j-th element indicates the probability of the segment belonging to the mobility pattern MP_j. For simplicity, we set one element to be 1 according to segment's mobility pattern. In practice, the mobility vector looks like $(0.8, 0.2, 0, 0, 0)$.

$\mathbf{R}^1$	Mobility vector
$R^1_{seg_1}$	$m^1_1 = (0, 0, 0, 1, 0)$
$R^1_{seg_2}$	$m^1_2 = (1, 0, 0, 0, 0)$
$R^1_{seg_3}$	$m^1_3 = (0, 0, 1, 0, 0)$
$R^1_{seg_4}$	$m^1_4 = (1, 0, 0, 0, 0)$
$R^1_{seg_5}$	$m^1_5 = (0, 0, 0, 1, 0)$

$\mathbf{R}^2$	Mobility vector
$R^2_{seg_1}$	$m^2_1 = (0, 0, 0, 0, 1)$
$R^2_{seg_2}$	$m^2_2 = (0, 1, 0, 0, 0)$
$R^2_{seg_3}$	$m^2_3 = (0, 0, 1, 0, 0)$
$R^2_{seg_4}$	$m^2_4 = (0, 1, 0, 0, 0)$
$R^2_{seg_5}$	$m^2_5 = (0, 0, 0, 0, 1)$

Table 4: Mobility vector for person 1 and person 2.

3 Adaptive mobility transition graph generation

3.1 Computing the node set V

In this step, we need to calculate the number of segments of each mobility pattern at time t, in other words, the weight of the node. For example, the size of node $V_1^{t=8}$ should be 1, because there is only one trajectory segment (m_2^1) belongs to mobility pattern MP_1. We show the weight of nodes at time 08:00, 10:00, 16:00 and 18:00 in Fig. 2.

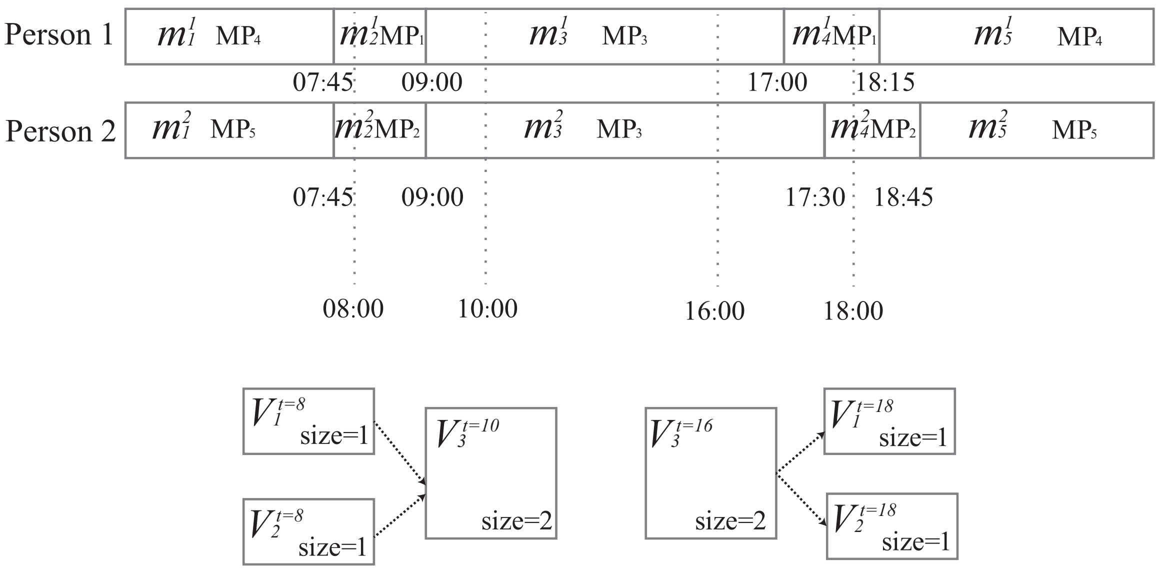

Figure 2: The process of graph generation.

3.2 Computing the edge set E

First, we want to show the overview of mobility transition at time point 07:00. There are two mobility pattern transitions that appear at 7:00 (m_2^1->m_3^1 and m_2^2->m_3^2). Person 1 transit from MP_1 to MP_3. Person transit from MP_2 to MP_3. We can estimate a transition matrix A to capture the process.

$$A = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

The element $a_{3,1} = 1$ and $a_{3,2} = 1$ indicate that the probability from MP_1 to MP_3 and from MP_2 to MP_3 is very high.

Second, we want to calculate transition matrix at time point 17:00. There is a transition from m_3^1 to m_4^1 at 17:00. And there is another transition from m_3^2 to m_4^2 at 17:30. Obviously, the former have more influence on transition matrix at 17:00. We may get a transition matrix like:

$$A = \begin{pmatrix} 0 & 0 & 0.7 & 0 & 0 \\ 0 & 0 & 0.3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

The element $a_{1,3} = 0.7$ and $a_{2,3} = 0.3$ indicate that the probability from MP_3 to MP_1 and from MP_3 to MP_2.

In addition, the transition matrix could be used to predict the next behavior of a user: $m_{new} = Am_{old}$. We set m_{old} as $(0, 0, 1, 0, 0)^T$, which means people stay at place B. We can find that people stay at place B tend to transfer into MP_1 at 17:00 with 70 percent probability.

$$m_{new} = \begin{pmatrix} 0.7 \\ 0.3 \\ 0 \\ 0 \\ 0 \end{pmatrix} = A \begin{pmatrix} 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{pmatrix}$$